Reduction of Stresses in a Root Section of Spur Gear

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***Abstract*- A gear is a component within a transmission device that transmits rotational Forces. Gears are commonly used for transmitting power. Gear teeth failure due to fatigue is a common fact observed. Even a small reduction in the root tensile stress results in great raise in the fatigue life of a gear. Hence the further study is carry out considering to improve fatigue life of spur gear. The stresses can be reduced by introducing a small hole near the root fillet. Also the stresses can be reduced by changing the radius of root fillet.**

***Index Terms*- Spur gear, Finite Element method, Root Fillet, Von mises stress.**

1. INTRODUCTION

A gear is a rotating machine part having cut like teeth, or cogs, which mesh with another toothed part to transmit torque. Geared devices can change the speed, torque, and direction of a power source. Gears almost always produce a change in torque, creating a mechanical advantage, through their gear ratio, and thus may be considered a simple machine. The teeth on the two meshing gears all have the same shape.[1] Two or more meshing gears, working in a sequence, are called a gear train or a *transmission*. A gear can mesh with a linear toothed part, called a rack, producing translation instead of rotation. A gear is a component within a transmission device that transmits rotational Forces. Gears are commonly used for transmitting power. Gear teeth failure due to fatigue is a common fact observed. Even a small reduction in the root tensile stress results in great raise in the fatigue life of a gear. They develop high stress concentration at the root and the point of contact. The repeated stressing on the fillets causes the fatigue failure of gear tooth. For many years, gear design has been improved by using better material, hardening surfaces with carburization and heat treatment, and shot penning to improve surface finish etc. Few more hard work have been made to improve the durability and strength by changing the pressure angle, using the asymmetric teeth, varying the geometry of root fillet curve and so on.

1.2. OBJECTIVE

The objectives of work are

- To analyze the bending stress in spur gear using FEM
- To study the effect of circular hole as a stress relieving feature for gear.

2. ANALYTICAL APPROACH

The force acting on the gear tooth and stresses induced are given as follows

Power , P = 3 KW

Speed , N = 1800 rpm

The torque obtained on the gear can be calculated as :

$$P = \frac{2\times\pi\times N\times T}{60}$$

$$T = \frac{3000\times 60}{2\times\pi\times 1800}$$

T = 15.91 $\times 10^3$ N-mm

Force is given by,

$$F = \frac{T}{r}$$

$$F = \frac{15.91 \times 103}{25}$$

F = 636.4 $\cong$ 640 N

Where,

F = Force acting on the tooth (N)

T = Torque acting on the tooth (N-mm)

r = Pitch circle radius (mm)

Tangential Force acting on the tooth, $F_t = F \cos \propto$

$= 640 \cos 20°$

$= 601.40 \cong 610$ N

Perpendicular Force acting on the tooth, $F_r = F \sin \propto$
$= 640 \sin 20°$
$= 218.89 \cong 220$ N

Bending Stress acting on the tooth, $\sigma_b = \frac{M}{Z}$
$= \frac{5490}{42.39}$
$= 129.51 \cong 130$ MPa

Compressive stress acting on tooth, $\sigma_r = \frac{Force}{Area}$
$= \frac{220}{90}$
$= 2.44 \cong 3$ MPa

3. MODELLING OF SPUR GEAR

The modeling of the spur gear is done by using CAD software. The model of gear is designed in the CREO 3.0. The following fig. shows the 3-D view of the spur gear.

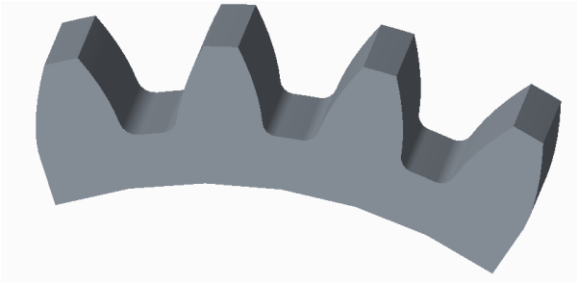

Fig.1. Geometry of 3-D modeled spur gear

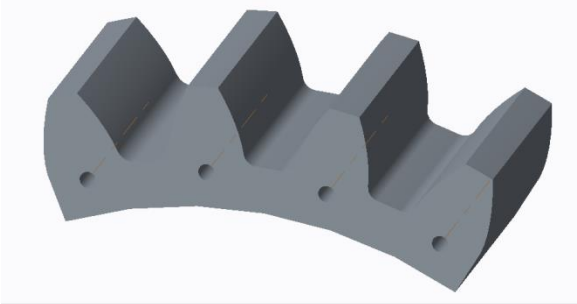

Fig.2. Geometry of 3-D modeled spur gear with hole

4. ANALYSIS OF SPUR GEAR

The analysis of spur gear is done by using ANSYS 14.0. The tangential load applied is 610 N and compressive load applied is 220 N. The results of analysis are shown below:

4.1. Importing Geometry to workbench.

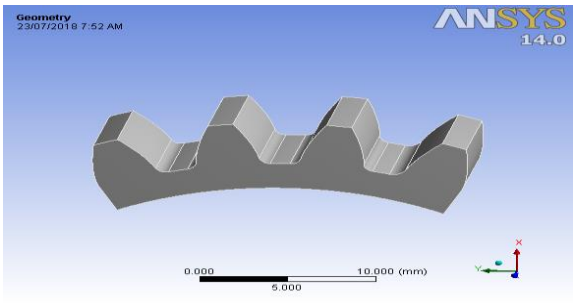

Fig.3. Geometry of spur gear

4.2. Meshing of Spur Gear

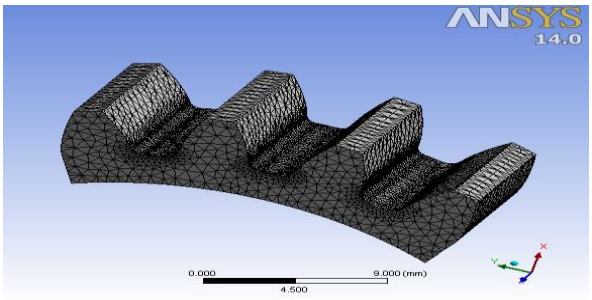

Fig.4. Meshing of spur gear

4.3. Applying Constrain to spur gear

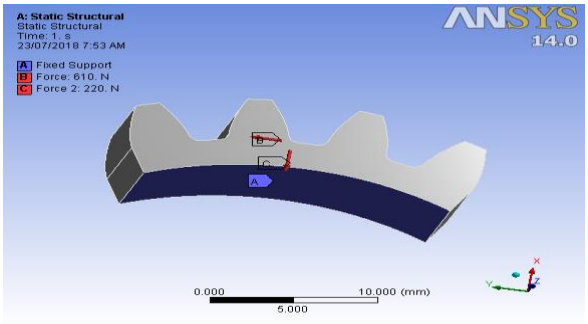

Fig.5. Constrain applied to spur gear

4.4. Results

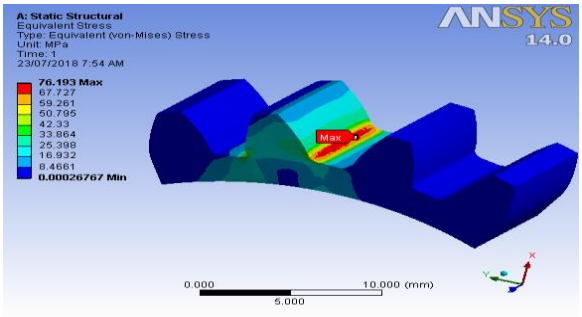

Fig.6. Stress contour of spur gear

Also the analysis of spur gear is carried out by varying the dimensions of root fillet radius and

diameter of hole introduced near to the root fillet radius.

5. ANALYSIS OF SPUR GEAR FOR STRESS REDUCTION BY INTRODUCING HOLE

5.1. STRESSES AT ROOT FILLET OF SPUR GEAR HAVING ROOT FILLET RADIUS 0.5 MM

The analysis of spur gear is carried out for the root fillet radius of 0.5 mm. A small hole is created near the root fillet of the teeth and analysis is carried out varying the diameter of hole. The analysis of spur gear is carried out for the hole diameter 0.8 mm, 0.9 mm, 1.0 mm, 1.1 mm and 1.2 mm. The following figure shows the results of analysis :

A. STRESS ANALYSIS OF SPUR GEAR HAVING HOLE OF 0.8 MM

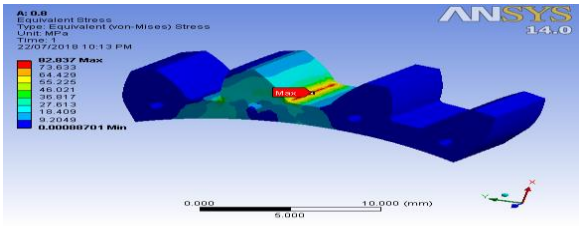

Fig.7. Stress contour of spur gear having hole diameter 0.8 mm

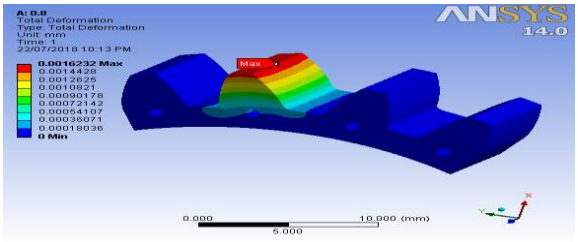

Fig.8. Deformation contour of spur gear having hole diameter 0.8 mm

B. STRESS ANALYSIS OF SPUR GEAR HAVING HOLE OF 0.9 MM

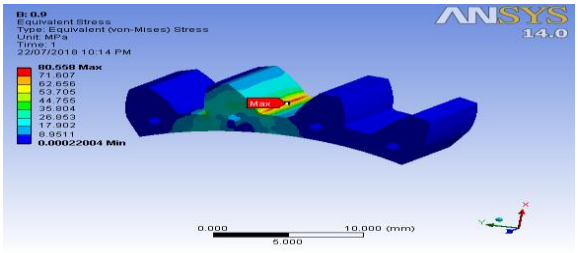

Fig.9. Stress contour of spur gear having hole diameter 0.9 mm

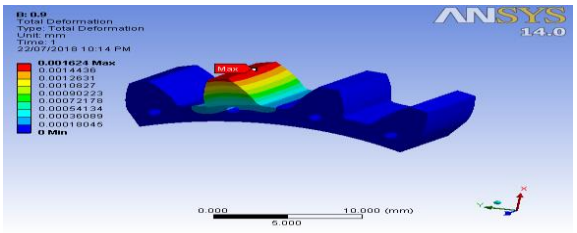

Fig.10. Deformation contour of spur gear having hole diameter 0.9 mm

C. STRESS ANALYSIS OF SPUR GEAR HAVING HOLE OF 1.0 MM

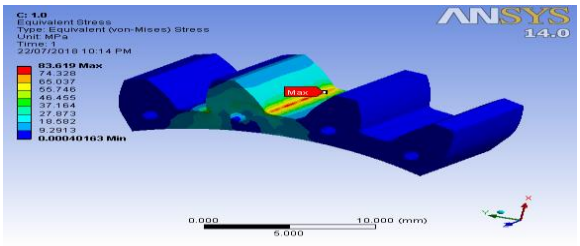

Fig.11. Stress contour of spur gear having hole diameter 1.0 mm

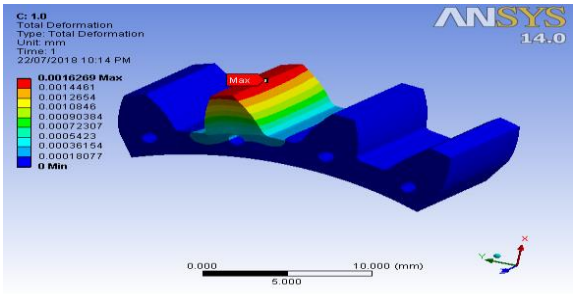

Fig.12. Deformation contour of spur gear having hole diameter 1.0 mm

D. STRESS ANALYSIS OF SPUR GEAR HAVING HOLE OF 1.1 MM

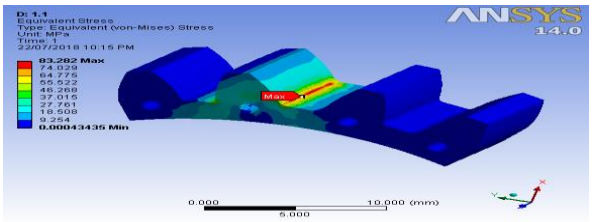

Fig.13. Stress contour of spur gear having hole diameter 1.1 mm

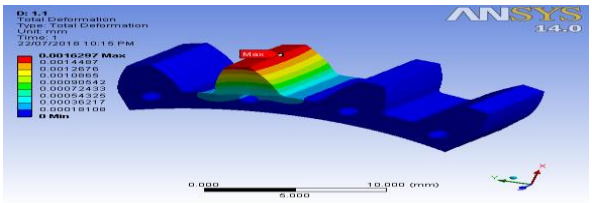

Fig.14. Deformation contour of spur gear having hole diameter 1.1 mm

E. STRESS ANALYSIS OF SPUR GEAR HAVING HOLE OF 1.2 MM

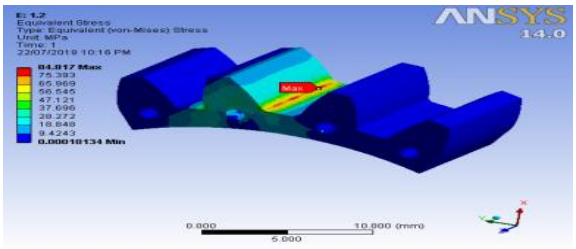

Fig.15. Stress contour of spur gear having hole diameter 1.2 mm

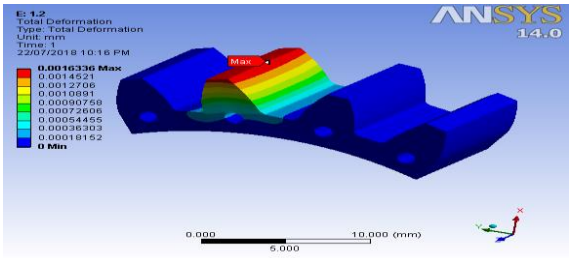

Fig.16. Deformation contour of spur gear having hole diameter 1.2 mm

Similarly the analysis is carried out for the root fillet radius 0.63, 0.8, 1.0 and 1.2. The result of the analysis is tabulated given below:

Diameter of hole \ Root fillet radius	0.63	0.8	1.0	1.2
0.8	74.916	65.295	58.48	52.89
0.9	74.272	66.723	59.54	55.11
1.0	73.548	66.54	58.35	54.50
1.1	74.368	65.722	59.89	55.83
1.2	74.052	67.023	61.59	55.36

Table 1. Result of analysis

6. RESULT

Stress at Root Fillet for hole diameter 0.8

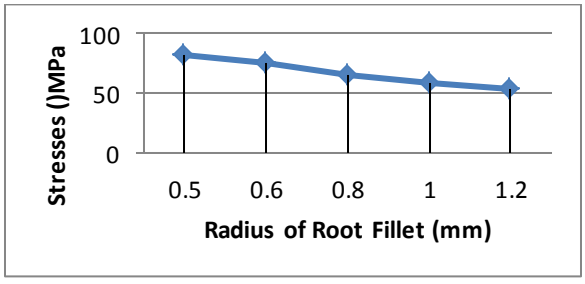

Fig.17. Comparison of Stress with the Root fillet radius 0.8

Fig.17 shows the stresses obtained on the root fillet of the gear tooth. It is observed that stress is decreases as the radius of root fillet increases.

Stress At Root Fillet for hole diameter 0.9

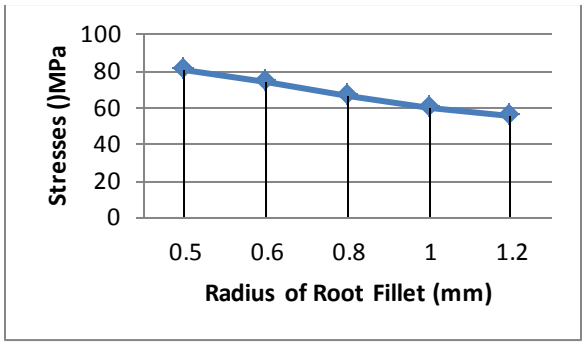

Fig.18 Comparison of Stress with the Root fillet radius 0.9

Fig.18 shows the stresses obtained on the root fillet of the gear tooth. It is observed that stress is decreases as the radius of root fillet increases.

Stress At Root Fillet for hole diameter 1.0

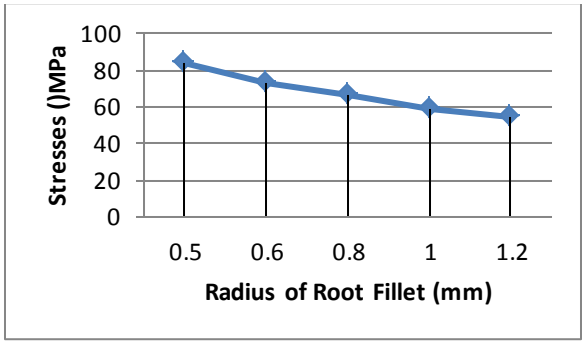

Fig.19 Comparison of Stress with the Root fillet radius1.0

Fig.19 shows the stresses obtained on the root fillet of the gear tooth. It is observed that stress is decreases as the radius of root fillet increases.

Stress At Root Fillet for hole diameter 1.1

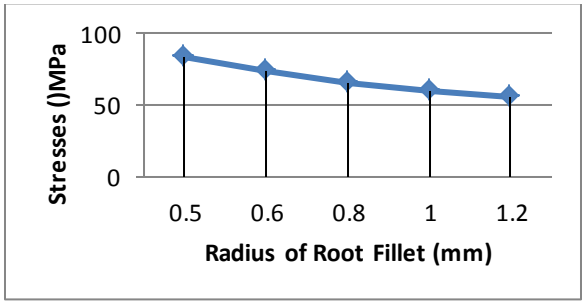

Fig.20 Comparison of Stress with the Root fillet radius 1.1

Fig.20 shows the stresses obtained on the root fillet of the gear tooth. It is observed that stress is decreases as the radius of root fillet increases.

Stress At Root Fillet for hole diameter 1.2

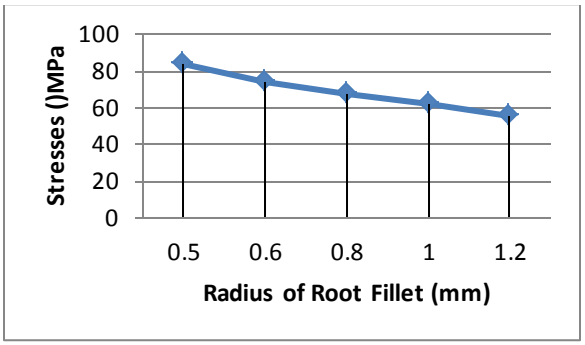

Fig.21 Comparison of Stress with the Root fillet radius 1.2

Fig.21 shows the stresses obtained on the root fillet of the gear tooth. It is observed that stress is decreases as the radius of root fillet increases.

7. CONCLUSION

- It is found that the stress induced at the root section with hole is lower than that without hole.
- It is observed that as the radius of fillet radius at root section increases, the stress at root section decreases.
- It is observed that there is random variation in stresses with increase in hole diameter. It is found that when diameter is 1 mm, the induced stress is minimum.

REFERENCES

[1] Nidal H. Abu-Hamdeh and Mohammad A. Alharthy "A Study on the Influence of using Stress Relieving Feature on Reducing the Root Fillet Stress in Spur Gear" Proceedings of the 2014 International Conference on Mathematical Methods, Mathematical Models and Simulation in Science and Engineering .ISBN 978-61804 -219-4 p.p 219-226

[2] V. Rajaprabakaran, Mr. R. Ashokraj " Spur gear tooth stress and analyses And stress Reduction" ISSN:2278-1684,P-ISSN:2320-334X p.p38-48

[3] Prof Vijay kumar Chalwa, Mr. Nagesh Kamanna, Asst Prof Prasad Nayak "Empirical relations to predict the probable percentage of reduction in root fillet stress in spur gear with circular stress relief feature" International Journal of Innovative Research in Science, Engineering and Technology Vol. [2] Issue 7, July 2013 p.p 198-208

[4] M. S. Hebbal, V. B. Math, B. G. Sheeparamatti , "A Study on Reducing the Root Fillet Stress in Spur Gear Using Internal Stress Relieving Feature of Different Shapes," International Journal of Recent Trends in Engineering, vol. [1] year 2009 , pp. 163-165,

[5] Dhavale A.S. Abhay Utpat "Study of Stress Relief Features at Root of Teeth of Spur Gear" International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. [3], Issue 3, May-Jun 2013, pp.895-899 .

[6] Vivek Singh, Sandeep Chauhan "Finite Element Analyses Of A Spur Gear Tooth Using Solid works Simulation And Stress Reduction By Stress Relief Hole" International journal of advanced scientific and technical research Issue 2 vol.[5], October 2012 p.p 213-219